National Aeronautics and
Space Administration
Goddard Space Flight Center
Greenbelt, Maryland
20771

September 10, 1993

Reply to Attn of: E. Masuoka/920.2

TO: MODIS Science Team Member
FROM: MODIS Science Data Support Team/E. Masuoka
SUBJECT: Updating information in the MODIS Science Computing Facility Plan

Enclosed is the latest version of the MODIS Science Computing Facilities Plan. I would appreciate any comments you have on the plan. However if you are pressed for time, the only section in the plan that you should look over carefully is Table 4 , which begins on page 31. This table describes the hardware and software you plan to purchase for your SCFs through the year 2001. I believe it accurately reflects your input to the SDST either by phone, e-mail or in the updated proposals you submitted as MODIS Team members. This section is our report to the Project on the computer systems we need to get the MODIS work done and as such may be used to determine the SCF portions of our budgets.

I would like to send the corrected plan to the EOS Project in mid-October. Please send your corrections to me c/o Barbara Conboy by October 10. We will have a new fax number starting October first. It is (301) 286-1757. Until the first, please send faxes to (301) 286-9200. If you have any questions, regarding the plan please contact me at emasuoka@ltpsun. Thanks for your help.

Ed Masuoka
Head, MODIS SDST

cc:
920/B. Conboy
920/D. Herring

MODIS Science Computing Facilities Plan

Version 1

Send Comments to:

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MODIS SCIENCE COMPUTING FACILITIES (SCF) PLAN

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MODIS SCIENCE COMPUTING FACILITIES (SCF) PLAN

1.0 INTRODUCTION

The MODerate-resolution Imaging Spectroradiometer (MODIS) is a passive Earth-radiation sensor scheduled for launch on the Earth Observing System (EOS) orbiting platform in 1998. MODIS senses reflected solar radiation during daylight hours and Earth-emitted thermal radiation (infrared) continuously (day and night).

Science products for the MODIS instrument will be developed and validated by a team of twenty-four Earth scientists selected for their expertise in instrument calibration, atmospheric science, ocean science, and land science. Since the team members were chosen for their scientific expertise, the team includes members with varying interests and abilities in data system implementation. To accommodate the individual differences, the MODIS Team Leader is allowing the science team members to themselves specify the extent to which they will develop the software they deliver to the project. Some team members may deliver prototype code that runs on the scientists home computing facility, and others may deliver full-up code, ready for operational use in the EOS-designated high-speed processing facilities.

Some required MODIS processing tasks are not included in any Science Team Member's domain of interest (e.g., basic MODIS Level-1 instrument data processing). To develop code to support this and to assist in porting scientist's code to operational data production facilities, the MODIS Team Leader has designated a software support group called the MODIS Science Data Support Team (SDST). The MODIS Team Leader Computing Facility (TLCF) is designed to provide the required computer support for the Team Leader. Each Team Member will have his own Science Computing Facility (SCF) to provide his required MODIS support. This document describes the functions to be performed by the TLCF and the SCFs, the required interfaces with other MODIS and EOS data groups, and the specific hardware needed to support near-term TLCF and SCF activities. This document presents an evolutionary approach to TLCF and SCF development, and it contains functional descriptions at each of several proposed phases of evolution.

In the near-term, the TLCF will support MODIS Level-1A and Level-1B algorithm development, development of the Level-2 Processing Shell, and integration of Team Members Level-2 algorithms. CASE tools, code checkers and optimization tools will be on the TLCF to the Team Members and SDST software developers. As the launch date approaches, the TLCF will support generation of simulated MODIS data, prototyping, development of test cases, testing at all levels, software optimization and configuration management. The TLCF will also support MODIS Team Member tasks which are too large to be done on the Team Member SCF and which are appropriate for the architecture of the TLCF (symmetrical multiprocessing but not massively parallel). In the post-launch era, the TLCF will continue the previous support in addition to supporting algorithm updating, refinement or replacement, the generation of special products, and quality assurance of products.

Individual MODIS Science Team Members will have Science Computing Facilities (SCF) in their laboratories for the development, testing and refinement of their algorithms, for the validation and quality assurance of their data products, and for the generation of Special Data Products (research products not scheduled for routine production). The SCF configuration will vary between Team Members according to their individual requirements.

The ocean science members of the MODIS Science Team have joined together to form the MODIS Oceans Team for coordination of their research. A special computing facility called the MODIS Oceans Team Computing Facility (MOTCF) is established at the University of Miami for supporting the coordinated development, testing and refinement of the oceans science algorithms, and for validation, quality assurance, and special product generation for the Oceans Team.

The SDST will integrate and optimize Team Member's code for the EOSDIS Core System (ECS), but the Team Members are responsible for coding their algorithms, and they retain responsibility for their algorithms throughout the lifetime of the MODIS experiment.

2.0 THE MODIS SCIENCE COMPUTING FACILITIES (SCF) ENVIRONMENT

The overall data system that supports the EOS program is called the EOS Data and Information System (EOSDIS). The EOSDIS includes data communications components that handle data transfer to and from the platform as well as other components that generate the commands to be transferred to the platform and interpret the data received from the platform. Instrument command generation and the scientific interpretation, storage, and distribution of EOS data will be done in a subset of the EOSDIS called the EOSDIS Core System (ECS). See Figure 1. The ECS provides an Instrument Command Center (ICC) for each individual instrument. Operational processing of instrument data to generate Earth-science products will be done in a sub-facility of the ECS called the Product Generation System (PGS), and storage and distribution of data will be done in another facility called the Data Archive and Distribution System (DADS). The data user interface to the DADS is handled by the Information Management System (IMS). The basic structure is as indicated in Figure 1. The ECS also contains other components that do not interface with MODIS processing.

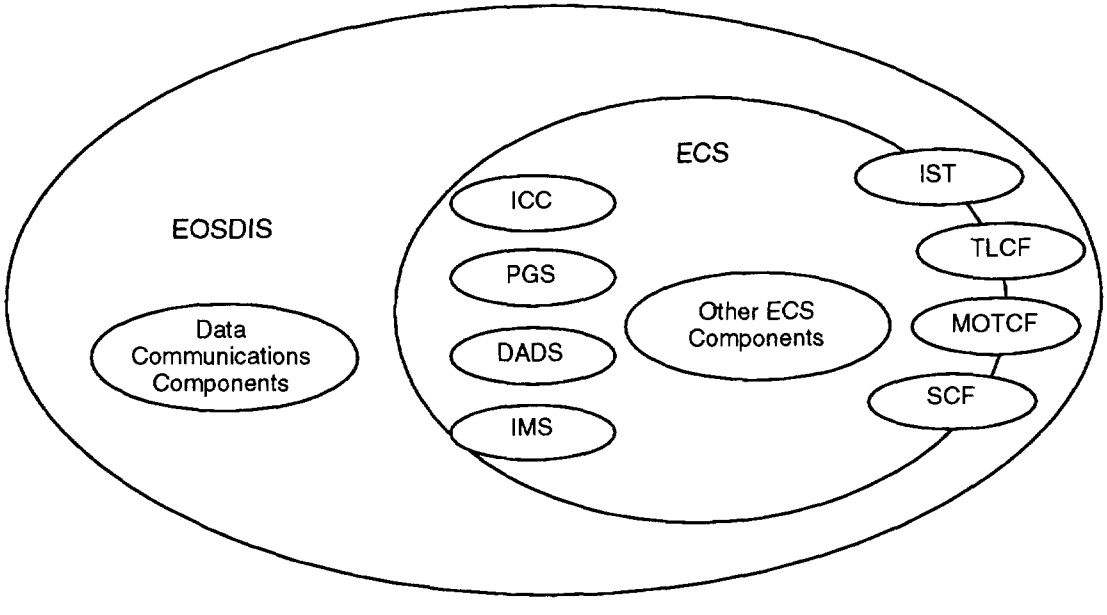


Figure 1 EOSDIS Structure and ECS components which interface with MODIS processing.

To allow the Science Team Leader (and possibly other Science Team Members)

to monitor instrument behavior and participate in instrument command decisions without being physically present at the ICC, the ECS will provide a software toolkit known as the Instrument Support Terminal (IST). The IST toolkit will run on a local terminal or workstation provided by the Team Leader, his designate, or other participating Team Members. The IST allows the Team Leader to interactively participate in instrument planning and scheduling, review engineering data, analyze instrument trends and investigate anomalies (as required), and interactively develop command requests.

The initial development of software to produce EOS Standard Products, the production of Special Data Products (research products generated for a subset of the available data and not scheduled for routine production on the PGS), the validation of Standard and Special Data Products, on-going quality control of Standard and Special Data Products and research activities of the Science Team Members will be done independently at the individual scientist's Science Computing Facility (SCF), on the Team Leader Computing Facility (TLCF) or on the MODIS Oceans Team Computing Facility (MOTCF). The relationship between ECS facilities and the ISTs and SCFs is defined in the ECS Specification, and this specification is the formal basis for many of the requirements and functional relationships cited in this document.

Besides basic IST and SCF functions related to instrument monitoring and control and the production and validation of science products, the MODIS Team Leader must also support other functions related to his unique position as team leader. To assist with these functions, the MODIS Team Leader has defined the three support groups shown in Figure 2. The SDST was discussed above. The MODIS Characterization Support Team (MCST) provides support related to monitoring and calibration of the MODIS instrument. The MCST is planning a near-real-time instrument monitoring effort that will examine segments of the MODIS instrument data as these data are returned from the observing platform. The MCST will do a number of instrument-related investigations and will use general purpose computing facilities as well as special purpose computers dedicated to the instrument monitoring task. The MODIS Administrative Support Team (MAST) will provide basic administrative support to the Team Leader and the Science Team and will use computers only for administrative tasks.

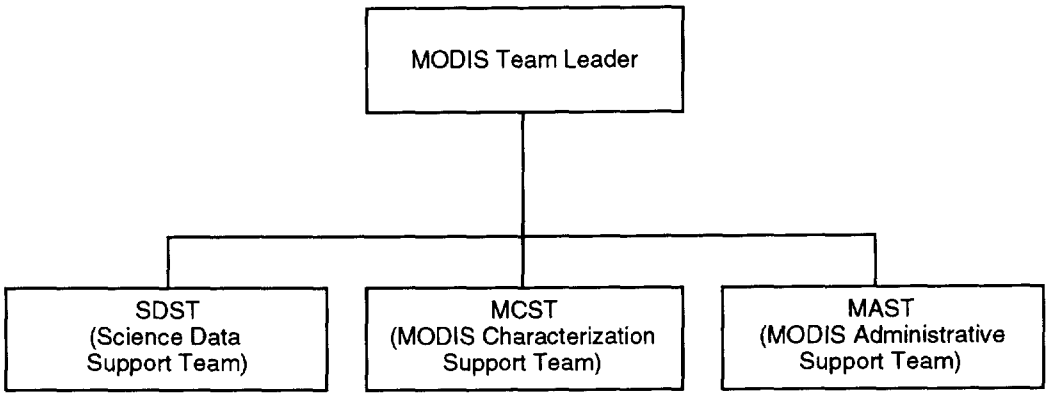


Figure 2. MODIS support teams.

The ECS specification defines the support that the TLCF (and an SCF) must provide to the ECS. Information flows is both directions across the interface between the ECS and the Team Leader's facility, and the basic nature of the relationship is indicated in Figure 3. To provide a high-level overview, the data flows between the ECS and the TLCF have been shown generically in the diagram, e.g. data flow between the ECS and the TLCF has been shown as "PGS-TLCF Support" and "DADS-TLCF Support". Figure 3 also shows other data system entities that interface with the TLCF. "External Data Sources" will provide Level-0 through Level-4 data products from non-EOS instruments that are needed for MODIS algorithm development and product validation. This is a one-way data flow from the external source to the TLCF. It is the responsibility of the Science Team Leader or Members to initially obtain the external data required to develop and validate their products.

The data flow diagram for the MODIS Oceans Team Computing Facility (MOTCF) is shown in Figure 4.

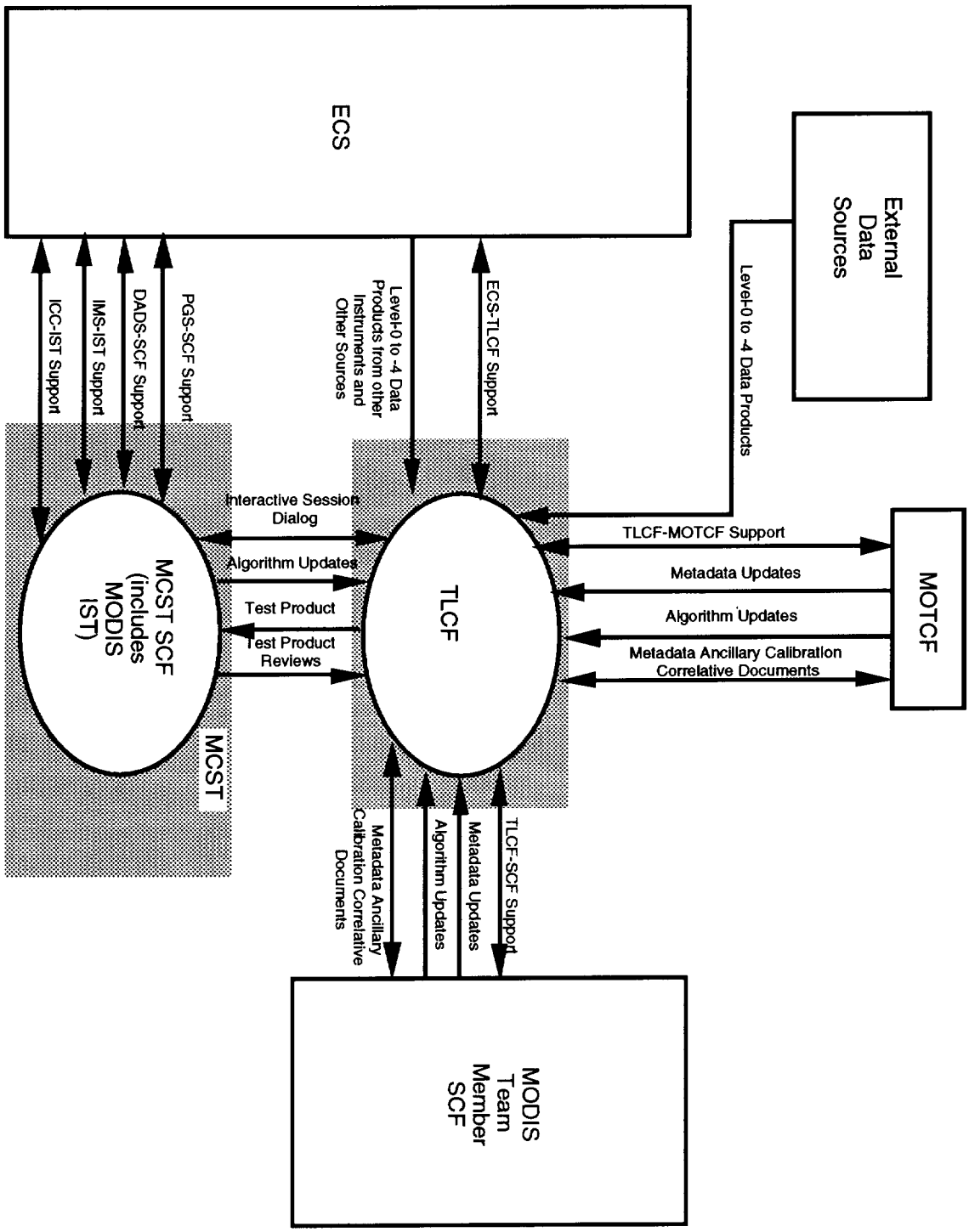


Figure 3 TLCF Data Flow Diagram.

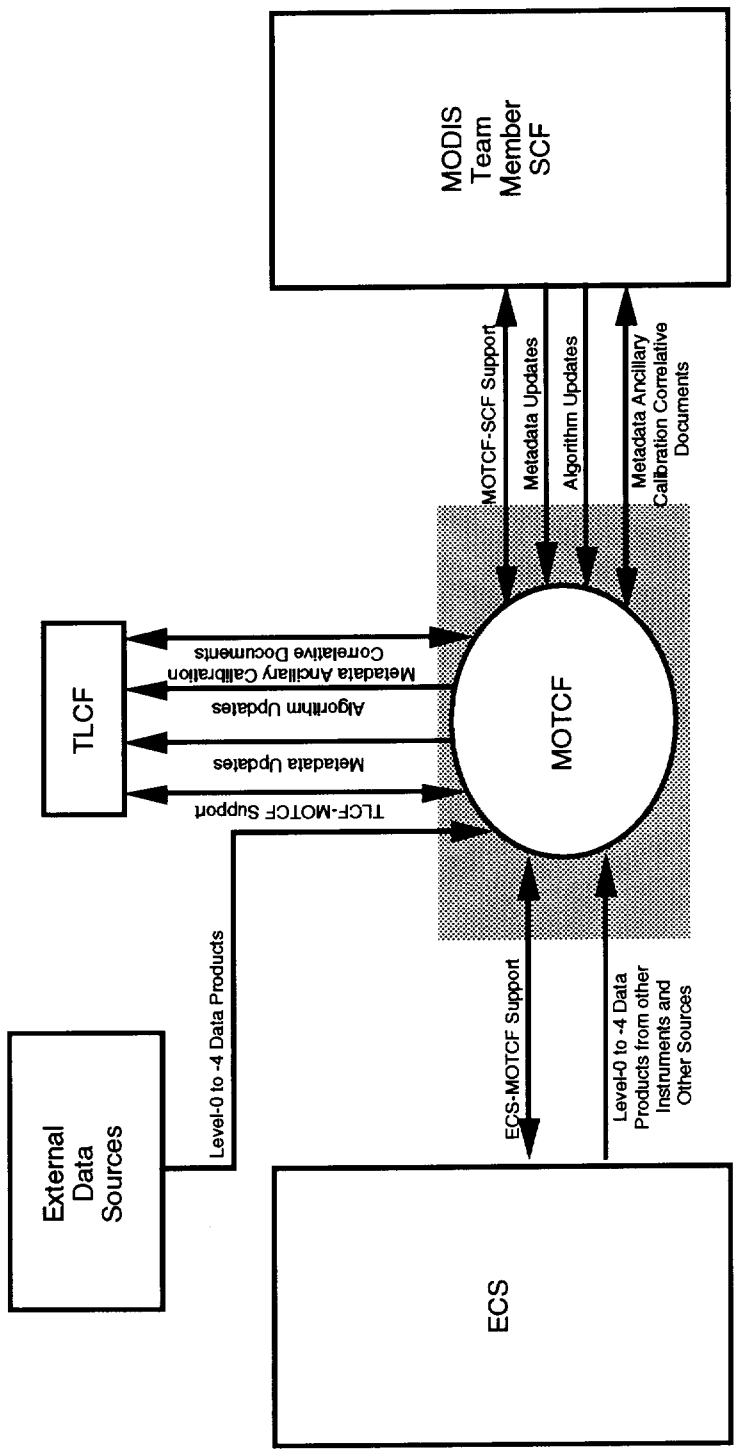


Figure 4 . MODIS Ocean Computing Facility Flow Diagram

The corresponding data flow diagram for a Science Computing Facility (SCF) is shown in Figure 5.

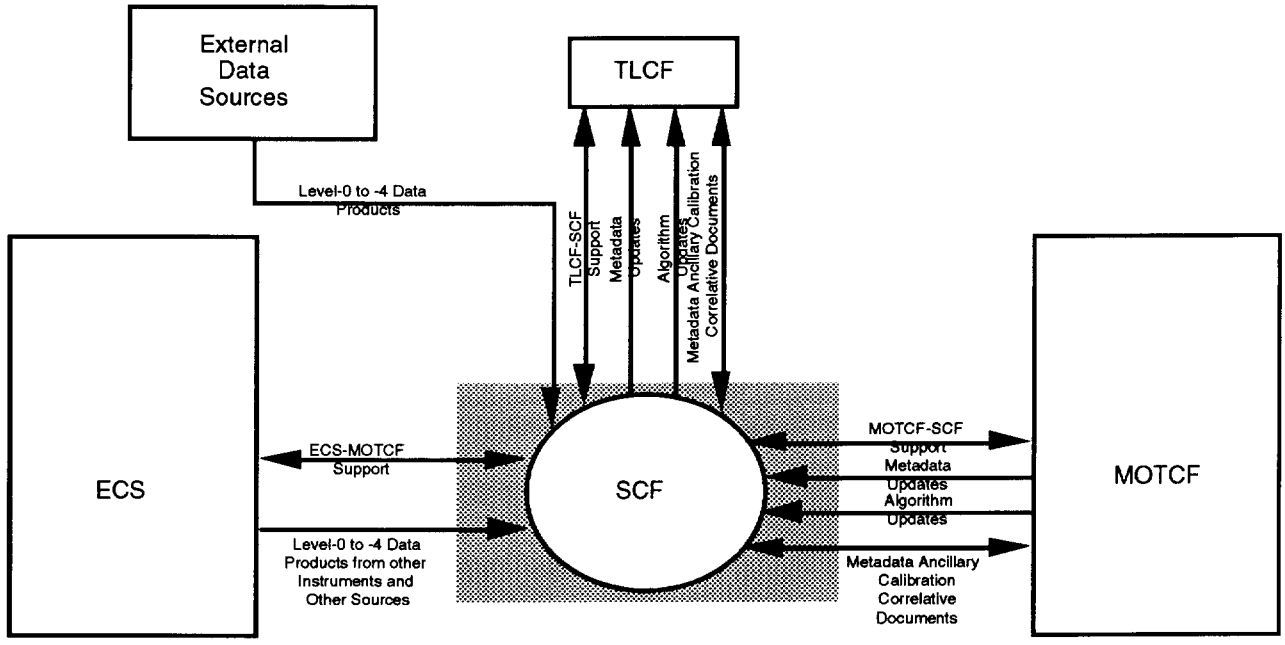


Figure 5. SCF Data Flow Diagram (Note: Only the Ocean Team's SCFs will have MOTCF connections.

A diagram showing the expanded definition of data flows between the ECS and a SCF or the MOTCF are given in Figure 6. Services to be provided to the MOTCF or SCF by the TLCF include porting of data product code from the MOTCF or SCF to PGS-compatible facilities, and the integration of multiple Team Member algorithms into a single, efficient, operational MODIS product generation system. Proper ordering of data product generation will minimize data input requirements and improve efficiency, i.e. if several algorithms requiring the same input data are run sequentially while the data is retained in memory, data is input only once for the entire procedure, and not once of each individual product algorithm.

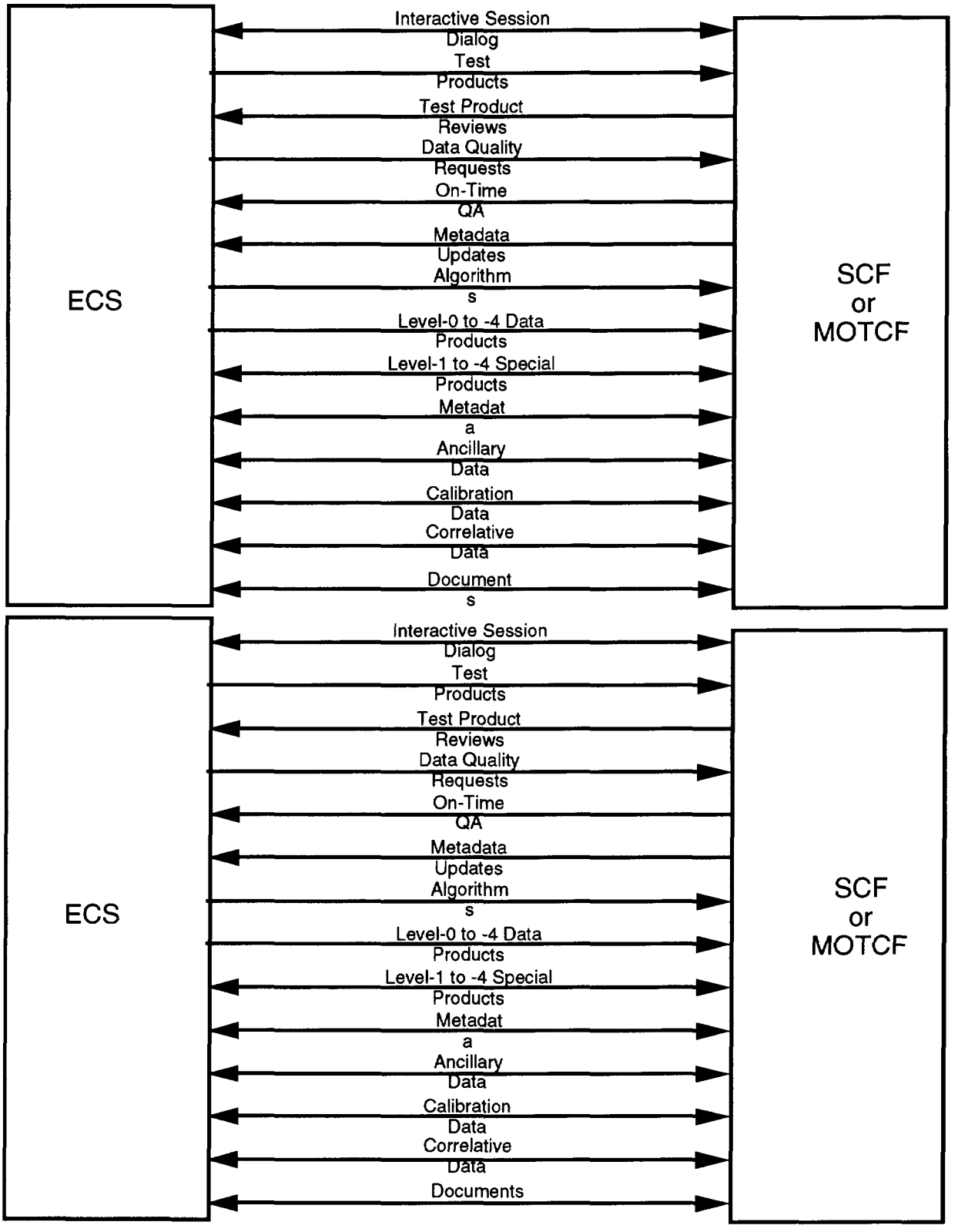


Figure 6. Expanded definitions of ECS-SCF support components.

A data dictionary defining the data flows is included as Appendix A to this document.

3.0 TLCF AND SCF DEVELOPMENT PHASES

The proposed TLCF development schedule is primarily determined by one key requirement related to software integration and testing. Although the ECS is developing a PGS toolkit that is intended to simulate the operational features of the PGS at the scientist's local SCF, it is expected that full cross-platform code portability from the SCF to the PGS cannot be assured and MODIS algorithm integration and testing at the TLCF will be done using facilities fully compatible with the operational PGS. Since algorithm integration and testing is critical to the timely completion of MODIS processing software by the launch date, integration and testing must begin as soon as possible, and the critical event shaping the development schedule is the availability of PGS-compatible hardware and software for TLCF use, along with algorithms from the Science Team (at least in prototype form). The PGS will first be defined in late 1994 but a PGS compatible system for the TLCF will not be installed until mid to late 1995 depending on procurement leadtimes. The proposed facility development schedule is shown in Figure 7.

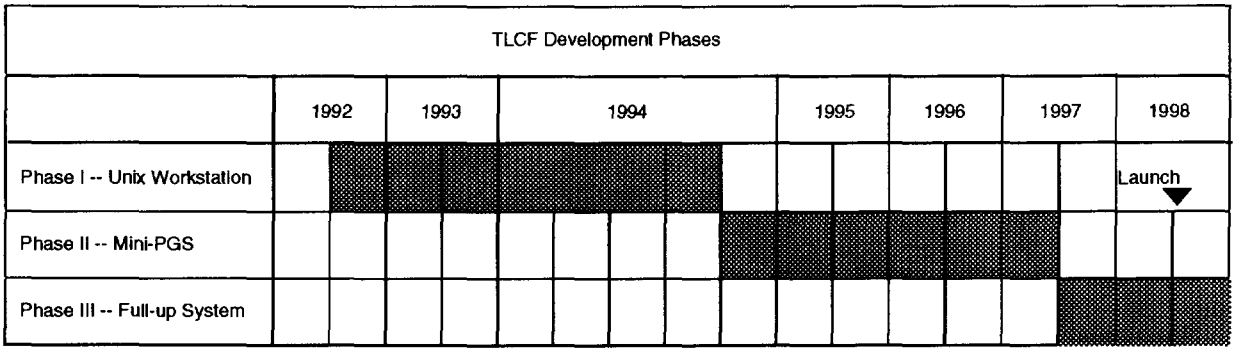


Figure 7. TLCF Development Phases.

The Phase I TLCF based on UNIX workstations and X-terminals will support the processing of prototype data sets obtained from MODIS precursor instruments, the development of MODIS Level-1 processing code and MODIS Level-2 processing shell, and integration testing of prototype science algorithms. The TLCF will also support the MODIS Land Team by providing a processing environment in which algorithms can be tested on a global AVHRR LAC dataset. The dataset will consist of 18 months of AVHRR data that will cover the globe at a resolution of 1 km. Team Members will be able to access the TLCF to run their algorithms and produce products that can be evaluated at the TLCF or at

their SCF.

The use of PGS-compatible facilities (Phase II) should begin in mid to late 1995. Most Science Team Members will be in early stages of testing at that time since many simulated MODIS data sets will still be in the developmental stages. Therefore it is expected that an entry level version of the PGS, or "mini-PGS" will be adequate to meet requirements. As testing becomes more processing and storage intensive the "mini-PGS" will be expanded to support the additional load.

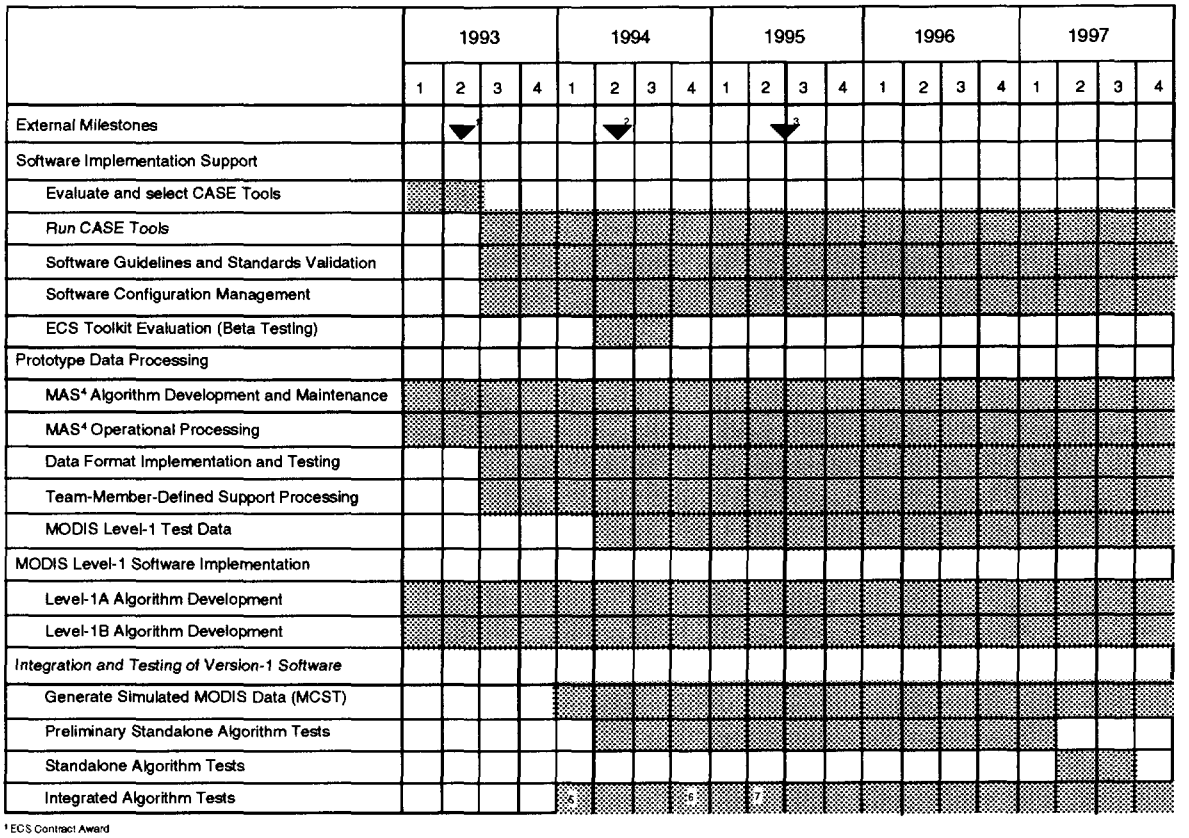
In the years preceding launch the prototype MODIS processing system in the PGS may be upgraded, replaced or augmented by computer system with a different architecture, e.g. massively parallel processors. The timing of the purchase of the PGS clone for the MODIS TLCF (Phase III) will depend on the selection of the final production systems for MODIS processing in the PGS. The PGS clone will be sized such that it could process all MODIS once. This will provide adequate processing resources to meet the requirements for software development, testing, validation, maintenance and quality assurance activities. By comparison, the MODIS processing system in the PGS will be ten times faster.

4.0 FUNCTIONAL REQUIREMENTS FOR THE TLCF, MOTCF AND THE SCFS

Many of the required TLCF functions can be inferred directly from the data flows shown in Figure 3. "PGS-TLCF Support" includes "Interactive Session Dialog" that supports general communication between the PGS and the TLCF for software integration and test. Algorithm Updates, Test Products, and Test Product Reviews support algorithm integration and test at the PGS. Algorithm Updates include the source code for the candidate algorithm, algorithm documentation, and a job step control skeleton that controls the execution sequence for the algorithm and the interchange of data with other programs being executed. Test products generated by the candidate algorithms are sent to the TLCF. Reviews of the test products are sent back to the PGS. Algorithm development, integration, and maintenance are some of the primary functions performed at the TLCF.

The relationship shown between the "TLCF" and the "MODIS Team Member

SCF" recognizes the potential support function that the "TLCF" may provide to other Science Team Members. Besides integration and testing support for MODIS algorithms, the TLCF may also perform routine QA of Team Member products, if the Team Member desires. These support functions are embodied in the "PGS-SCF Support" flow between the TLCF and the Team Member SCF. Also, if the Team Member desires, the TLCF may support the production of Special Products for the Team Member. The Team Member will perform the QA of such products and the Team Member will supply "Metadata Updates", as shown, to complete the QA field in the metadata for such Special Products. "Data Group 1" data flows are also related to potential Special Product generation at the Team Member SCF.



[1] ECS Contract Award
[2] PDR-PGS Architecture Chosen (approx.)
[3] PGS-compatible machine delivered (approx.)
[4] MODIS Airborne Simulator (MAS) or a successor instrument
[5] Team Member Version 0 code at SDST for integration and testing (with selected TIMs, not contractually required), simulated data needed
[6] Review progress, make changes
[7] Team Member Version 1 code due at SDST for integration and testing

Functions performed by the Team Leaders Computing Facility.

The relationship shown between the TLCF and the MCST SCF includes all aspects of the Team Leader relationship with any other SCF except that the TLCF is not likely to provide routine QA of data products for the MCST nor is it

likely to produce Special Products for the MCST. The TLCF does support the integration and testing of MCST algorithms.

In addition to supporting formal functional relationships expressed in data flow diagrams and discussed above, the TLCF will also provide a number of short-term and special purpose support services for the MODIS Science Team. Figure 8 is a list of Team-Leader-unique support functions identified thus far in the effort. Since the Team Leader is responsible for providing services not otherwise provided within the Science Team, this list will evolve as implementation progresses and new needs are identified. For each function, the figure shows an associated time interval during which the support service is thought to be needed.

The MODIS Ocean Team's Computer Facility (MOTCF) houses computer systems for the development of MODIS Ocean processing software. Individual Ocean Team members have UNIX workstations for visualization, small scale algorithm development and analysis of products. The MOTCF serves as the focal point for large scale simulation, algorithm development, storage and processing of large precursor data sets and testing system designs for the integrated Ocean algorithms.

Validation of data products routinely produced at the PGS is an SCF function. This includes routine production Quality Assurance (QA) and post production QA. Routine production QA information is used to fill in the QA fields of the product metadata as the product is shipped to the DADS. Post production QA information goes directly to the DADS as "Metadata Updates".

Another SCF function is research investigations. If desired, the Team Member may access other scientist's algorithms stored at the DADS to support his own development efforts. Also to support his investigations at the local SCF, the Team Member may access "Data Group 1" items including Metadata on data items stored at the DADS, Ancillary, Calibration, and Correlative data, and algorithm documentation, as well as "Level-0 to -4 Data Products" for other instruments and "Level-1 to -4 Special Products" produced at other Team Member SCFs within the EOSDIS. Such investigations may or may not result in useful data products to be shared with other investigators. If not, the Team Member effort is a simple research investigation. If useful products are produced, these products are to be shared with other investigators and are

known as Special Products. Special Products with their associated metadata and documentation are transferred from the SCF to the DADS.

The "Level-0 to -4 Data Products" flow from "External Data Sources" recognizes the fact that not all data needed by a Team Member for a scientific investigation will be available from the DADS. The Team Member can best identify appropriate "External Data Sources" for his investigation.

5.0 NETWORKING AND COMMUNICATIONS REQUIREMENTS

The basic networking and communications requirements for the TLCF, MOTCF and Team Member SCFs can be derived from the data flow diagram shown in Figures 3 and 6 together with data volume information.

The TLCF interfaces with PGS and DADS components of the ECS, with "External Data Sources", with the respective SCFs of other MODIS Science Team Members, and with the MCST portions of the TLCF. Of these, the TLCF, major portions of the MODIS PGS and DADS, the MCST SCF, and several MODIS Team Member SCFs are expected to be located at Goddard Space Flight Center (GSFC) and can use presently-existing (during Phase I) and enhanced (for Phase II and III) networking capability provided for EOS use at the Center.

The MOTCF interfaces with the SCFs of the MODIS Ocean Team, the SeaWiFS processing system at GSFC, the TLCF and a massively parallel Connection Machine (CM-5) at Oregon State University. A high speed network link between Miami, GSFC and Oregon State has been proposed to support advanced algorithm development by members of the Ocean Team. A SONET OC-1 (50Mbps) link is proposed in the near-term and will be increased to OC-3 (150Mbps) then to OC-12 (640Mbps) to meet algorithm development and communication needs in the years preceding launch.

A Team Member SCF interfaces with other SCFs, the ESDIS Core System at the DAACs, the TLCF and/or the MOTCF. Large data sets may be transferred between an SCF and the other facilities during algorithm development, quality assurance and validation activities. Where a high volume of data will be transferred between facilities and the cost of a high speed network would be prohibitive, magnetic tape (DAT, 8mm or D3 in a 3480 form factor) or optical media will be used. The TLCF, MOTCF and other large computational facilities

may be accessed from an SCF in order to: test software in an environment similar to the PGS, to run larger tests of the software on high speed computational and file servers or to conduct research on new algorithms using a different architecture, i.e. massively parallel computing. In these instances results of the computations will need to be transmitted to the SCF through a high speed network to allow interactive analysis and algorithm development.

5.1 The ECS Interface

All MODIS Level-1 Data Products will be produced and stored at the Goddard Space Flight Center (GSFC). The production and storage of MODIS Level-2 through Level-4 products will be distributed across three data centers as shown in Table 1. Besides GSFC, the contributing centers are the Earth Resources Observation System (EROS) Data Center (EDC) in Sioux Falls, South Dakota and the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. All MODIS atmospheric and ocean products will be produced and stored at GSFC. Level-2 land products will also be produced at GSFC. Level-3 and 4 land data products will be produced at EDC and Level-2 through Level-4 snow and ice products will be produced at NSIDC.

Table 1
Production and Storage of MODIS Level-2 through Level-4* Data Products

		Level-2	Level-3	Level-4
Atmospheric	PGS	GSFC	GSFC	GSFC
	DADS	GSFC	GSFC	GSFC
Ocean	PGS	GSFC	GSFC	GSFC
	DADS	GSFC	GSFC	GSFC
Land	PGS	GSFC	EDC	EDC
	DADS	EDC	EDC	EDC
Snow/Ice	PGS	NSIDC	NSIDC	NSIDC
	DADS	NSIDC	NSIDC	NSIDC

* All MODIS Level-1 Data Products are produced and stored at GSFC.

In order to refine and test algorithms at the TLCF in the years following launch, global MODIS data will be transferred to the TLCF from the GSFC DAAC on a monthly basis. These data will be loaded onto networked near-line storage in the TLCF. The test data sets are sized at 24.5 Terabytes which is based on the volume of MODIS Level 1A, 1B and Level 2 data for 78 days (one day each week for a year and one full month of days). Three approaches for transferring

the data between the DADS in the GSFC DAAC and the MODIS TLCF are described below.

A design that does not require compatible hardware in the DADS and TLCF is shown in Figure 9. In this design a near-line silo in the TLCF is connected to the DADS via a HIPPI switch. Today only a few silos support high speed network connections while most, like the StorageTek silo shown in Figure 9 attached to a computer in the DADS, must be accessed through a host system. By 1996 we assume that most silos will support high speed network transfers independent of a host system, as is shown on the TLCF side of the diagram. If one wanted to transfer 24.5TB each month, a conservative estimate of the data rate required is 30Mbyte/sec which would complete the transfer in two weeks. This allows for downtime and instances where the DADS might not maintain a 30Mbyte/sec transfer to the TLCF due to other priorities. In this design near-line storage is provided by a StorageTek silo, whose optical tape drives handle a sustained transfer rate of at least 10Mbytes/sec. Our assumption is that a silo with these capabilities will be available sometime in FY 94 or 95 since D2 based tape libraries already exist with higher transfer rates per drive. Of the 16 drives available with a StorageTek silo 3 or more drives could be dedicated to tape ingest and up to 13 additional tape drives could be added to support data transfers to compute servers in the TLCF through a HIPPI switch. This solution is proposed in the TLCF design but either of the options described below would fit within the TLCF budget.

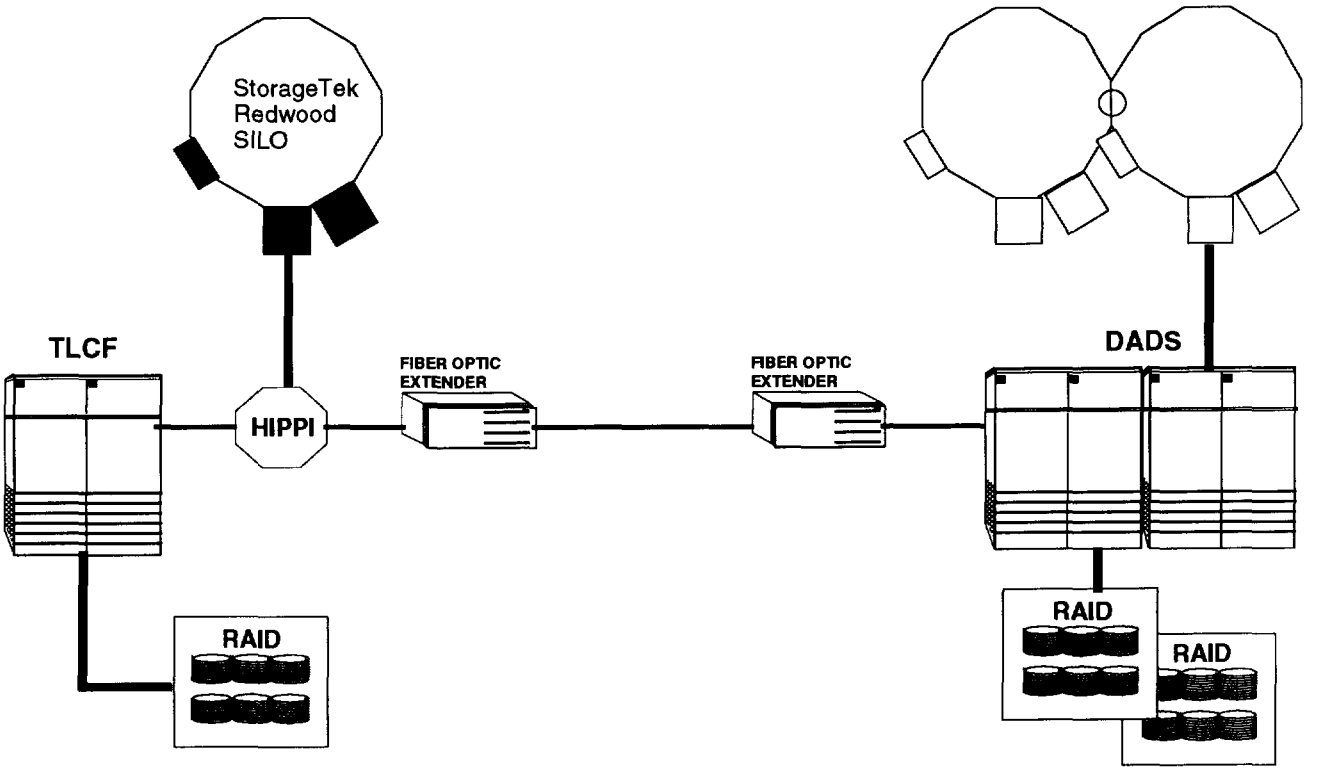


Figure 9. One solution for data transfer from GSFC DAAC to MODIS TLCF

If the DADS in the GSFC DAAC distributes the data in a format compatible with the near-line storage library in the TLCF a high speed network connection would be unnecessary. Writing high capacity optical or magnetic tapes and shipping the tapes between the EOSDIS and Earth System Science Building would permit more rapid data transfer rates than could be achieved via the first design. This approach, however, requires that the DADS support high capacity optical or magnetic media and that the near-line storage system in the TLCF be compatible with that of the DADS.

A third possibility is that the distribution media provided by the DADS will be incompatible with the near-line storage system in the TLCF and no HIPPI connection exists. In this event, a separate computer system would be required to read the data from the distribution media and write it into the near-line storage. A multiprocessor system could be employed to support multiple tape or optical drives. If we assume that the average storage capacity and data transfer rate of an 8mm tape drives doubles every two years, by 1996 a tape cartridge will hold 20GB and have an sustained transfer rate of 2Mbytes/sec. Fifteen drives would provide the throughput required to transfer a complete test data set to nearline storage within two weeks.

Besides the local links within GSFC, two distant link requirements remain for the ECS-interface. PGS-SCF Support for Level-3 and 4 land products is required with the EDC in Sioux Falls, SD and PGS-SCF Support for Level-2, 3, and 4 snow and ice products is needed with the NSIDC in Boulder, CO. Examination of PGS-SCF Support as defined in Figure 5 reveals two basic functions that are involved: integration and testing of product algorithms at the remote sites and routine QA of operational products produced at the remote sites by either the TLCF staff or staff at the SCFs. Communications to support integration and testing will be needed only sporadically and will likely involve only relatively small volumes of data to be transferred. The communications requirement for routine QA are potentially larger and data volumes for this function will be defined in the Software and Data Management Plan.

5.2 The "External Data Sources Interface

SCF communications with "External Data Sources" could potentially involve a large segment of the worldwide Earth-science community. The EOSDIS Science Network (ESN) (to be developed by the ECS contractor) will provide gateway access to the NASA Science Internet (NSI), which will, in turn, provide the required access to the worldwide community. In the near-term, the SCF will also have access to Internet services, and it is expected that most required access to "External Data Sources" can be handled via existing Internet services.

5.3 Team Member SCF Interface

Although data transfer volumes for SCFs could be appreciable, most of the functions supported are not operationally pressing, and short delays in communications response may be tolerable. Since most of the ocean product code is being developed and integrated at the University of Miami, communications requirements between SCFs and that facility may be particularly large. The Ocean Team's proposed high speed network could be utilized to link the TLCF, SCFs and the GSFC DAAC with the MOTCF in the event that large data sets need to be transferred on a regular basis.

5.4 The TLCF-MCST Interface

The TLCF and the MCST SCF will share some physical facilities at GSFC. For the

near-term , it appears that data communications requirements between those components which are can be adequately handled by the existing GSFC Ethernet network. If data transfer requirements increase beyond the capabilities of the existing Ethernet, a FDDI network will be used to link components of both computing facilities. Once the main compute servers of the TLCF and MCST SCF are collocated in the Earth System Sciences Building in 1997 a gigabit/sec network will be installed to connect the compute and file servers.

5.5 Communications Requirements

Network requirements are summarized for the SCFs, TLCF and MOTCF in Table 2. The required rates and functions are identified for each phase of SCF evolution from the current rate to the at-launch rate. The at-launch rate network should be in place at least six months prior to launch to insure that it will be operational by launch.

6.0 MODIS Team Leader's Computing Facility 1992-2000

The development of the MODIS TLCF is described in the following sections. Section 6.1 describes its initial phase as a collection of workstations used for software development and prototyping MODIS algorithms. Sections 6.2 and 6.3 describe its evolution from the initial phase to its post-launch configuration of PGS clones, where large tests on long time series data sets are performed to test improvements in the MODIS processing software.

6.1 THE PROPOSED PHASE I TLCF

Specific plans have been made to procure a Phase I (pre-1995) TLCF which will support software development by the SDST and algorithm testing and data processing activities of the MODIS Land and Atmosphere Teams. The TLCF will include UNIX based computer systems and X-terminals supporting: software development, processing of MODIS Airborne Simulator (MAS) data, digitizing and GIS activities directed at producing databases for algorithm development and product validation. Each element of the Phase I system is described below.

By 1994 roughly fifteen developers will be involved in the design, coding, documentation and testing of MODIS data processing software. The code design, development and documentation processes will be automated through

Table 2 Communication network for MODIS SCFs. Where three rates are separated by dashes the first is the current network bandwidth, second is an intermediate bandwidth and the third is the at-launch required bandwidth. Rates are in Megabits/sec. Internet means available Internet speeds..

Investigator	Location, Team	Access to TLCF	Access to MOTCF	Access to GSFC DAAC	Access to EDC DAAC	Access to Other sites
Abbott	Oregon State University, Ocean	Internet	50-150-622 ATM/SONET	Internet		Ocean SCFs 50-150-622Mbps
Brown	University of Miami, Ocean	Internet	50-150-622 ATM/SONET	Internet		Ocean SCFs 50-150-622Mbps
Carder	University of South FL, Ocean	Internet	10-45-100	Internet		Ocean SCFs 50-150-622Mbps
Evans (MOTCF)	University of Miami, Ocean	50-150-622 ATM/SONET	100-1,000	50-150-622 ATM/SONET		Ocean SCFs 50-150-622Mbps
Esaias	GSFC, Atmos	10-100	10-100	10-100		GSFC SCFs 10-100Mbps, other SCFs via Internet
Gordon	University of Miami, Ocean	50-150-622 ATM/SONET	50-150-622 ATM/SONET	50-150-622 ATM/SONET		Ocean SCFs 50-150-622Mbps
Hall	GSFC, Land	10-100		10-100	Internet	GSFC SCFs at 10-100Mbps, other SCFs via Internet
Hoge	Wallops Isl.	Internet	Internet	Internet		Ocean SCFs via Internet
Huete	Univ of Ariz, Land Team	Internet		Internet	Internet	Land SCFs via Internet
Justice	GSFC, Land	10-100		10-100	Internet	GSFC SCFs at 10-100Mbps, other SCFs via Internet
Kaufman	GSFC, Atmos	10-100		10-100		GSFC SCFs at 10-100Mbps, other SCFs via Internet
King	GSFC, Atmos	10-100		10-100		GSFC SCFs at 10-100Mbps, other SCFs via Internet
MCST	GSFC, Support	10-100-1,000		10-100-1,000		Other SCFs via Internet
Menzel	NOAA NESDIS, Ocean	Internet	Internet	Internet		Other SCFs via Internet
Running	Univ of MT	Internet		Internet	Internet	Other SCFs via Internet
Salomonson	GSFC, Land	Internet		Internet	Internet	Other SCFs and NSIDC via Internet
SDST (offsite progammer team)	Maryland, Support	1.5-45-150	Internet	1.5-45-150	Internet	Internet

Investigator	Location, Team	Access to TLCF	Access to MOTCF	Access to GSFC DAAC	Access to EDC DAAC	Access to Other sites
SDST (TLCF)	GSFC, Support	10-100-1,000	50-150-622Mbps ATM/SONET	10-100-1,000	Internet	Ocean SCFs at 50-150-622Mbps, GSFC SCFs at 10-100Mbps Other SCFs via Internet
Slater	University of AZ, Calibration	Internet		Internet		Other SCFs via Internet
Strahler	Boston Univ, Land	Internet		Internet	Internet	Other SCFs via Internet
Vanderbilt	ARC, Land	Internet		Internet	Internet	Other SCFs via Internet
Wan	UCSB, Land	Internet		Internet	Internet	Other SCFs via Internet

the use of CASE tools specifically: CADRE Technologies Team*work*; Hewlett-Packard's SoftBench for interactive code development and debugging; FrameMaker for document preparation and a software configuration management package that is compatible with the configuration management package used in the EOSDIS PGS. These tools will be hosted on UNIX workstations and accessed via workstations, X-terminals and personal computers running X-Windows.

By mid-1994, 5 workstations, 10 X-terminals and 3 personal computer systems will be located at the software development facility to support design, coding, documentation and testing. The workstations in the software development facility will reflect the mix of workstation in the SCFs. Providing a SDST programmer with access to a computing environment similar to that of the SCF at which the algorithm is being developed will allow the programmer to work closely with developers at the SCF and allow the process of integrating, testing and returning code for further development to proceed rapidly. This is crucial to the success of SDST software integration efforts since once an algorithm is integrated into a MODIS data processing package all changes should be made to the integrated version of that algorithm and any delays in integration and testing delay software development at the SCF.

In the paragraphs which follow the computing systems which make up the other component of the MODIS TLCF, the data processing facility, are listed and their current functions or proposed uses are described.

A multi-processor Silicon Graphics computer serves as the test bed for MODIS algorithms prototyping activities. The computer system has four R-4000 processors, 20GB of online disk storage, two 9 track tape drives and an Exabyte based jukebox. Test data sets consisting of global 1km AVHRR data will be maintained on the jukebox. The Exabyte tape drives will also be used to backup online disk storage and to transfer large data sets to MODIS investigators testing software in the TLCF.

MODIS airborne simulator (MAS) data are processed on a Silicon Graphics Indigo workstation and the Silicon Graphics Challenge XL compute server. Calibrated radiances for MAS data are produced with routines developed in conjunction with Dr. Michael King atmosphere research team.

A Sun and several Silicon Graphics workstations support image processing and GIS activities. PCI's EASI/PACE software package is used for image analysis and ESRI's ARC/INFO supports digitizing and GIS activities.

The current Ethernet networks connecting portions of the TLCF are sufficient to handle the data transmission requirements of the Phase I systems. A T1 line (1.544Mbits/sec) will connect the software development facility to Internet and from there to the TLCF and Team Member SCFs.

The 1993 TLCF is staffed with an operator shared with the Laboratory computing facility, who assists with MAS data processing. A shared programmer-analyst and system administrator will be added in 1994 to support workstations and the development of the MODIS data processing prototype. Each of these individuals supports other projects in the Laboratory for Terrestrial Physics Computing Facility and the level of support for MODIS activities is approximately 1.25 man-year.

6.2 Phase II TLCF (1995-1997)

When a computer system has been defined for the GSFC DAAC Product Generation System (PGS) in late 1994, a smaller version of that system, the "mini" PGS, will be purchased for the MODIS TLCF. This system will permit the SDST to test MODIS algorithms in an environment, which is functionally identical to that of the DAAC.

While the architecture of this PGS is not known, the mass storage required for testing algorithms in the "mini PGS" can be estimated. At present, roughly 85GB of storage are required to hold MODIS input data and output products for 2 orbits. Given that a number of algorithms require data over a period of weeks and that algorithms may require different data sets for testing, a reasonable estimate for storage is 850 GB of online space. To test algorithms which require data at intervals over the course of a year a minimum of 25TB of near-line storage will be required. A near-line storage system will be purchased in the 1997 time frame. It is anticipated that the system will transfer data at 30MBytes/sec and be based upon a tape silo utilizing optical tape in 3480 form factor and robotics retrieval mechanisms. However, the most appropriate networked near-line storage will be purchased at that time.

6.3 Phase III TLCF (1998-2000)

In 1998 a "full-up" version of the final PGS system will be purchased. This system will be used to test proposed changes to algorithms which are running in the ESDIS PGS and will allow the Science Teams to develop and refine algorithms with large MODIS data sets. It is anticipated that the process of refining science and calibration algorithms will be an iterative one and that changes to many algorithms will be made and tested daily. Once a Science Team member is satisfied with his or her changes to an algorithm it will be tested by the SDST and the new version of the MODIS production software will be submitted to the ESDIS DAAC for testing prior to replacing the existing MODIS production software. In order to perform testing and algorithm development in a timely fashion the MODIS system will be sized to allow the processing of all MODIS data once. The current estimate of the required processing speed is 7 GFLOPs. Online storage available for testing software will be 1.5Terabytes at launch with plans to expand it to 3.5Terabytes by 2001. The near-line storage system purchased in 1997 should provide at least 150TB of storage . It will be upgraded as needed to avoid obsolesce though a requirement for more than 150TB of nearline storage is not anticipated.

As wide area networks connecting SCFs and DAACs are upgraded to 155Mbps or faster and gigabit backbones are installed between DAACs, the network in the GSFC TLCF will be upgraded to a gigabit/sec network connecting workstations, the main computing systems for MODIS data processing and high speed storage devices. We anticipate that the NASA Science Internet Office at NASA Ames will upgrade the network link between the GSFC computing facility and the software development facility from 1.5Mbps to 50-100Mbps as our requirements for data transfer increase and as the cost for these higher network speeds drops.

Staffing in the Phase III TLCF will include an operator, a system programmer, a programmer/analyst, and one or more data technicians to assist SCFs in monitoring the data quality of individual products on a routine basis after launch. Each of these individuals will work full time on the MODIS project.

The hardware and software purchases for the TLCF from 1992 through 2000 are summarized in Table 3 for both the software development facility at the off-site contractor's facility and the main data processing systems housed in the

GSFC computing facility. Upgrades to workstations, personal computers and X-terminals needed to maintain an effective computing systems are budget for in the "Maint., upgrades" line item for each year. We currently plan to upgrade, trade-in or replace workstations and personal computers on 3 year centers to take advantage of advances in technology. Advances in technology, budgetary considerations, and experience gained in the software development processes for MODIS may alter both the mix of workstations, personal computers and X-terminals purchased over the years and the frequency with which each is upgraded.

7.0 Team Member SCFs

The MODIS Science Team members will have several classes of computing systems at their SCFs. The first class is composed of those computers on which software that runs in an EOSDIS PGS will be developed and tested. These computers, which host the PGS Toolkit, are workstation class or larger systems that run an EOS approved software environment. These systems are first purchased in 1993 and 1994 and will be expanded to in 1997 in order to handle the volume of MODIS data that will be needed for testing and debugging software after launch . Prior to 1997 each investigator will purchase or upgrade systems based on individual algorithm development needs.

A second class of systems are personal computers and workstations used for analysis of data, administrative functions and preparation of research papers. The computers used to prepare documents that will be delivered to the Project or other instrument teams for mark-up will run one of the EOS approved word processing packages. Beyond this there are no software requirements for this class of system.

A third class of system are those which are PGS compatible. These systems, found in the TLCF and the MOTCF, will be capable of the PGS scheduling software, operating system, processing scripts and have hooks . At a minimum systems will be capable of keeping up with the processing all the MODIS data or all the MODIS Ocean Products. While the ESDIS is being scaled at many times the processing power required to keep up with the production of all MODIS products, these smaller systems in the central Team facilities will be large enough to support the testing and development of the MODIS software in

Table 3. Hardware, and software purchases for MODIS TLCF from 1992 to 2001. Quantities are shown in parentheses.

Year	Software Development	Data Processing System
1992	HP 9000/730 2GB disk storage 64MB memory CADRE TeamWork(3) HP Softbench (3) NCD X-terminals (2) Macintosh Quadra	SUN SparcServer 670MP 2GB disk 64MB memory ARC/INFO NCD X-term (2) CALCOMP digitizer KODAK XL 7700 color hardcopy unit
1993	SGI Indigo 2 workstation HP Laserjet 4siMX X-terminals (4)	SGI Challenge XL multi-processor 20GB disk storage Two tape drives SGI Indigo 2 workstation X-terminals (2) Exabyte drive based jukebox
1994	Sun workstation 30K IBM R6000 40K DEC AXP workstation 40K X-terminals (4) 16K CASE Tools (Code checkers, Config. mgmt software) 45K Personal computers (2) 14K Supplies including UPS 12K Maintenance, upgrades 40K Total 230K	Upgrade Challenge XL R4000 processors to MIPS SRR processors and add 768KB memory 210K 100GB RAID disk 175K Sybase RDBMS software 20K X-terminal (3) 12K Software 45K FDDI network for workstations 30K Shared laser film recorder 25K Personal computer (2) 14K Supplies 12K Maintenance, lisc., upgrades 42K Total 585K

Year	Software Development		Data Processing System	
1995	UNIX workstations (4)	160K	Entry level Version 1 PGS	700K
	X-terminal (3)	16K	200GB disk	200K
	laser printer	6K	Software	60K
	Software	20K	Supplies	15K
	Supplies, UPSes	17K	Maintenance, lisc., upgrades	70K
	Maintenance, upgrades	78K		
	Total	285K	Total	1,045K
1996	Workstations (2)	70K	Expand PGS	750K
	X-terminals (3)	15K	500GB RAID disk	750K
	FDDI LAN	40K	Software and Supplies	50K
	Software and supplies	30K	Maint., upgrades	110K
	Maint., upgrades	90K		
	Total	240K	Total	1,660K
1997	Software and supplies	40K	Near-line storage (silo with D3 or	
	Maint., upgrades	160K	optical in 3480 form factor)	1,600K
			HIPPI network to DADS	200K
			Software and supplies	50K
			Maint., upgrades	300K
	Total	200K	Total	2,150K
1998	UNIX workstations (3)	90K	Entry level final version PGS	1,400K
	laser printer	6K	600GB disk	900K
	Software and supplies	54K	UNIX workstations for Q/C (2)	90K
	Maint., upgrades	120K	Software and supplies	50K
			Maint., upgrades	420K
	Total	270K	Total	2,860K
1999	X terminals (3)	12K	Expand PGS	1,000K
	Personal computers (2)	10K	Add 1,000GB disk	1,000K
	Software and supplies	58K	Color Hardcopy Unit	20K
	Maint., upgrades	120K	Software and supplies	60K
			Maint., upgrade disk drives	520K
	Total	200K	Total	2,600K

Year	Software Developers		Data Processing System	
2000	Color printer	10K	Expand and upgrade PGS	1,000K
	Software and supplies	60K	1,000GB disk	1,000K
	Maint., upgrades	150K	Software and supplies	60K
			Maint., upgrades	600K
	Total	220K	Total	2,660K

a production environment with large (multi-terabyte) datasets.

A fourth class of systems are those whose architecture and operating system differ from the processing strings chosen for the PGS but which have MFLOPs equaling or exceeding those of a PGS. Massively parallel computers capable of TeraFLOPs fall into this category. These computers will be used for testing new algorithms or doing complex calculations to produce lookup tables which will in turn be used in the production of the standard products. Depending on the application and the evolution of the PGS these systems might be used for producing some standard products in the PGS at a future date. There are no restrictions on the software or hardware for these systems, since they will not host the PGS Toolkit.

MODIS Team Member SCF purchases are summarized in Table 4 for the period from 1993 to 2000. Needless to say predictions about future developments in computing and future prices are often inexact at best. With this in mind, the tables provide only general descriptions of the computing systems and software which will be purchased beyond 1995.

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
Abbott	Desktop Workstation	$11,000	Upgrade Existing SGI Processing System	$97,000	Visualization Workstation	$101,000	Visualization Workstation with disk storage	$75,000	File Server with heirarchical storage management	$163,000	Massively Parallel Processor (MPP) Data Processing System
Abbott					Additional Memory and Disk Storage for SGI Processing System	$42,000	Additional Memory for SGI Processing System	$10,000	Processing System Upgrades	$225,000	Disk Storage for MPP System
Abbott					Graphics Software	$20,000	Upgrade existing workstations	$81,000	Disk Storage	$100,000	Three Desktop Workstations
Abbott					Networked Print Server	$18,000	Optical Jukebox	$50,000	Video display & recorder	$50,000	CD-ROM Jukebox
Abbott							Fiber Channel Network	$75,000	Network Equipment (SONET/ATM)	$23,000	
Abbott							Color Output Device	$25,000			
Abbott Total		$11,000		$97,000		$181,000		$316,000		$561,000	
Brown	Printer modem	$10,000	Printer modem	$10,000	Printer modem	$10,000	Printer modem	$10,000	Printer modem	$10,000	Printer modem
Brown	(Networking)	$2,230	(Networking)	$2,355	(Networking)	$2,487	(Networking)	$2,626	(Networking)	$2,773	(Networking)
Brown	Software Maintenance	$10,000	Software Maintenance	$10,000	Software Maintenance	$10,000	Software Maintenance	$15,000	Software Maintenance	$15,000	Software Maintenance
Brown	Computers	$50,000	Computers	$50,000			Computers	$50,000	Computers	$100,000	Computers
Brown	Maintenance	$30,000	Maintenance	$30,000	Computer Maintenance	$30,000	Maintenance	$30,000	Computer Maintenance	$40,000	Computer Maintenance
Brown	Supplies	$10,000	Supplies	$10,000	Supplies	$10,000	Supplies	$15,000	Supplies	$6,934	Supplies
Brown Total		$112,230		$112,355		$62,487		$122,626		$174,707	
Carder			Upgrade existing DEC	$30,000	Upgrade another	$33,000	DEC AXP/4000 class	$92,000	Upgrade network to	$50,000	Additional FDDI
Carder			Add SCSI 2 controller	$12,000	Add 4GB storage	$8,000	Add 5GB disk storage	$9,000	Add 10GB disk storage	$11,000	Add 16GB disk storage
Carder			Magneto-optical drive	$5,000	10GB Optical Jukebox	$10,000	Upgrade Optical	$10,000	Upgrade Optical	$15,000	Upgrade DEC
Carder			Color Printer	$7,000	Color scanner and slide maker	$7,000	Network router	$8,000	Film recorder	$11,000	
Carder					UNIX-based PC for ship data collection	$8,000	UNIX-based PC for ship data collection	$7,000	UNIX-based PC for ship data collection	$7,000	UNIX-based PC for ship data collection
Carder							(2) UNIX based PCs	$10,000	(3)UNIX based PCs for	$11,000	(2)UNIX based PCs for
Carder Total				$54,000		$66,000		$136,000		$105,000	
Clark	compute server (SGI Challenge class)	$114,000					High performance computing system	$128,000			
Clark	20GB disk storage	$20,000	15GB disk storage	$15,000					25GB disk storage	$25,000	20GB disk storage
Clark			Image display	$15,000					workstations	$40,000	workstation
Clark	printers	$6,000	printers	$3,000	printers	$3,000			printers	$6,000	printers
Clark	Software Licenses	$27,000	Software Licenses	$22,000	Software Licenses	$22,000	Software Licenses	$52,000	Software Licenses	$22,000	Software Licenses
Clark	upgrades	$5,000	upgrades	$5,000	upgrades	$25,000	upgrades	$5,000	upgrades	$5,000	upgrades
Clark							Network	$20,000			
Clark					UPS	$2,000	UPS	$2,000	UPS	$2,000	
Clark			Personal computers	$30,000							Personal computers
Clark	installation	$4,000							installation	$4,000	
Clark	maintenance	$5,000	maintenance	$10,000	maintenance	$20,000	maintenance	$25,000	maintenance	$25,000	maintenance

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
Clark	supplies	$5,000	supplies	$5,000	supplies	$5,000	supplies	$5,000	supplies	$8,000	supplies
Clark Total		$186,000		$105,000		$27,000		$237,000		$137,000	
Esaias					Workstations	$50,000					
Esaias	Upgrades/Memory	$8,000	Upgrades/memory	$18,000	Upgrades/Memory	$18,000	Upgrades/Memory	$18,000	Upgrades/Memory	$18,000	Upgrades/Memory
Esaias	Image Display/monitor	$10,000					Image Display/Monitor	$10,000			
Esaias	Software Lic.	$20,000	Software Lic.	$20,000	Software Lic.	$20,000			Software Lic.	$40,000	Software Lic.
Esaias	Media(Optical	$10,000	Media(Optical		Media(Optical	$40,000	Media(Optical	$10,000	Media(Optical	$20,000	Media(Optical
Esaias					Magneto-optic Jukebox	$75,000					
Esaias	Printers/Modems	$5,000	Printers/Modems	$5,000	Printers/Modems	$10,000	Printers/Modems	$5,000	Printers/Modems	$5,000	Printers/Modems
Esaias							Server-Micro	$100,000			
Esaias	Networking	$5,000	Networking	$5,000	Networking	$5,000	Networking	$5,000	Networking	$5,000	Networking
Esaias	Documentation	$2,000	Documentation	$2,000	Documentation	$5,000	Documentation	$5,000	Documentation	$5,000	Documentation
Esaias	Personal Computers	$15,000							Personal Computers	$15,000	
Esaias							Installation	$10,000			
Esaias	Maintenance	$20,000	Maintenance	$20,000	Maintenance	$20,000	Maintenance	$20,000	Maintenance	$20,000	Maintenance
Esaias	Supplies	$10,000	Supplies	$10,000	Supplies	$10,000	Supplies	$10,000	Supplies	$10,000	Supplies
Esaias					UPS	$4,000			UPS	$4,000	
Esaias Total		$105,000		$80,000		$257,000		$193,000		$142,000	
Evans					Workstations (Small)	$25,000			Workstations (Large)	$100,000	
Evans	Software Lic.	$10,000	Software Lic.	$10,000	Software Lic.	$10,000	Software Lic.	$10,000	Software Lic.	$10,000	Software Lic.
Evans	(Disk, Tape) Media	$50,000	(Disk, Tape) Media	$50,000	(Disk, Tape) Media	$50,000	(Disk, Tape) Media	$50,000	(Disk, Tape) Media	$75,000	(Disk, Tape) Media
Evans	Disk System, Mem.	$90,000									Disk System, Mem.
Evans	Interfaces	$20,000	Interfaces	$20,000	Interfaces	$20,000	Interface	$20,000	Interfaces	$20,000	
Evans	Display, Printers	$10,000	Display, Printers	$10,000							Display, Printers
Evans	Printer, Film Sup.	$25,000	Printer, Film Sup.	$25,000	Printer, Film Sup.	$25,000	Printer, Film Sup.	$25,000	Printer, Film Sup.	$25,000	Printer, Film Sup.
Evans							Computers	$500,000			
Evans					Archive System	$250,000					
Evans	Maintenance	$150,000	Maintenance	$150,000	Maintenance	$150,000	Maintenance	$150,000	Maintenance	$150,000	Maintenance
Evans	Video Equip	$5,000	Video Equip	$5,000			Video Equip	$5,000	Video Equip	$5,000	Video Equip
Evans Total		$300,000		$270,000		$530,000		$760,000		$385,000	
Gordon	(4) Decstation to DEC	$34,000			DEC AXP 3000/400	$11,000	(3) AXP Class	$72,000	Network, mass storage	$45,000	Network, mass storage

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
Gordon	64MB Memory for DEC	$3,000	192MB Memory for	$7,000	laser printer	$2,000	320MB Memory for	$32,000			
Gordon	(3) 3.5GB disk drives	$10,000	(3) 4.5GB disk drives	$11,000	(2) 4.5GB disk drives	$7,000	6.5GB Disk Drives	$18,000			
Gordon	laser printer	$2,000			Ethernet Crossbar	$10,000	(3) 1.5GB DAT Drives	$5,000			
Gordon							High Quality Color	$10,000			
Gordon					Maintenance	$6,000	Maintenance	$8,000	Maintenance	$15,000	Maintenance
Gordon Total		$49,000		$18,000		$36,000		$145,000		$60,000	
Hoge	Upgrades	$8,000	Memory	$10,000	Upgrades	$8,000					Upgrades
Hoge					Displays	$30,000					
Hoge			Software Lic.	$3,000					Software Lic.	$8,000	
Hoge			Drives	$15,000							
Hoge							Printers	$10,000			
Hoge							Networking	$10,000			
Hoge	Personal Computers	$6,000			Personal Computers	$6,000					
Hoge					Installation	$5,000					
Hoge	Maintenance	$3,000	Maintenance	$3,000	Maintenance	$3,000	Maintenance	$3,000	Maintenance	$3,000	Maintenance
Hoge	Supplies	$4,000	Supplies	$4,000	Supplies	$4,000	Supplies	$4,000	Supplies	$4,000	Supplies
Hoge Total		$21,000		$35,000		$56,000		$27,000		$15,000	
Huete					Workstations	$64,000	Workstations	$20,000	Workstations	$25,000	
Huete							Memory	$33,227	Memory	$18,700	Memory/Upgrades
Huete			Monitors	$700	Image Display	$30,000					Monitors
Huete	Software Lic.	$8,000	Software Lic.	$8,450	Software Lic.	$6,000	Software Lic.	$24,000	Software Lic.	$25,416	Software Lic.
Huete					Drives	$8,000	Drives	$8,456			
Huete	Printers	$5,000			Printers	$10,000			Printers	$10,000	Printers
Huete			Networking (Ethernet)	$1,200	Networking (Ethernet)	$1,266					Networking (Ethernet)
Huete											Documentation
Huete	Mainframe Computers	$1,056	Mainframe Computers	$1,115	Mainframe Computers	$11,176	Mainframe Computers	$5,243	Mainframe Computers	$7,350	Mainframe Computers

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
Huete	Personal Computers	$7,000	Personal Computers	$7,392							Personal Computers
Huete	Maintenance	$5,200	Maintenance	$6,598	Maintenance	$8,234	Maintenance	$17,200	Maintenance	$20,472	Maintenance
Huete					Installation	$6,000			Installation	$6,000	Installation
Huete	Operations (Supplies)	$4,600	Operations (Supplies)	$4,858	Operations (Supplies)	$8,000	Operations (Supplies)	$8,456	Operations (Supplies)	$8,955	Operations (Supplies)
Huete Total		$30,856		$30,313		$152,676		$116,582		$121,893	
Justice			Upgrade (2) HP 9000 workstations to HP 9000/735	$20,000	HP Compute Server with 192MB RAM, 1.3 disk drive	$76,000	Upgrade compute server, add 256MB RAM and 8GB disk	$63,000	Second UNIX server	$100,000	High performance image processing system
Justice			Add memory to HP workstations	$20,000	4GB disk drive	$4,000	HP workstation 755 CRX-24Z with 256MB RAM and 3GB disk drive	$80,000	Additional memory for both servers	$50,000	20GB disk storage
Justice			Sun Sparc workstation with 2GB disk drive and DAT drive	$30,000	32GB Rewritable optical library	$40,000	Upgrade optical library to 64GB	$25,000	LAN hardware and network management software	$50,000	High capacity RAM disk
Justice			4mm tape drive with autofeeder	$7,000			8mm 10 tape autoloader and 5GB drive	$12,000			4mm and 8mm drives with autofeeders
Justice			GIS software (ARC/INFO)	$20,000			Macintosh computer with 21" display	$10,000	(3) Macintosh computer systems	$30,000	Optical and magnetic media
Justice			color scanner	$2,000			color printer	$10,000			high resolution color printer
Justice			Matrix film recorder	$15,000							
Justice			Supplies	$6,000							
Justice Total				$120,000		$120,000		$200,000		$230,000	
Kaufman	Workstations	$10,000	Workstations	$10,000	Workstations	$10,000	Workstations	$100,000	Workstation	$20,000	Workstations
Kaufman	Mainframe Computers	$20,000	Mainframe Computers	$20,000	Mainframe Computers	$20,000	Mainframe Computers	$20,000	Mainframe Computers	$20,000	Mainframe Computers
Kaufman	Personal Computers	$6,000	Personal Computers	$6,000	Personal Computers	$6,000	Personal Computers	$6,000	Personal Computers	$6,000	Personal Computers
Kaufman Total		$36,000		$36,000		$36,000		$126,000		$46,000	
King	RDM	$35,000	workstation to R4400	$5,000	server	$103,000	to SGI ONYX	$78,000			system
King	computers	$40,000	computers	$40,000	computers	$40,000			Quadra computers	$30,000	
King	IDL license	$3,000	6 user IDL license	$15,000	Image film recorder	$10,000	Spyglass)	$10,000	Upgrade color printer	$15,000	

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
King	Spyglass Transform Visualization Software	$1,000	Spyglass Transform 6 user license	$6,000	color scanner	$2,000	SGI R4400 Indigo class workstation	$35,000	Upgrade (2) Indigo workstations	$30,000	
King			5GB disk system	$5,000	10GB disk system	$10,000	10GB disk system	$10,000	20GB disk system	$20,000	40GB disk system
King					(3) Color X-terminals	$15,000					(3) Color X-terminals
King			Color Printer	$15,000	support	$10,000			Powerbooks	$10,000	
King					laser printer	$5,000					laser printer
King					CD ROM Mastering System	$10,000					
King total		$79,000		$86,000		$205,000		$133,000		$105,000	
MCST	SW	$5,120	SW	$8,760	Professional Support SW	$27,100	SW	$27,750	SW	$28,250	SW
MCST	Scientific Analysis SW	$79,500	Scientific Analysis SW	$112,521	Scientific Analysis SW	$231,722	Scientific Analysis SW	$327,666	Scientific Analysis SW	$378,382	Scientific Analysis SW
MCST	Computer Systems	$130,073	Computer Systems	$152,722	Computer Systems	$433,690	Computer Systems	$596,818	Computer Systems	$679,603	Computer Systems
MCST	optical drives, etc.)	$65,000	optical drives, etc.)	$68,356	optical drives, etc.)	$157,468	optical drives, etc.)	$239,063	optical drives, etc.)	$273,658	optical drives, etc.)
MCST	Maintenance & Supplies	$56,200	Maintenance & Supplies	$62,704	Maintenance & Supplies	$68,344	Maintenance & Supplies	$128,231	Maintenance & Supplies	$138,258	Maintenance & Supplies
MCST	Data: TM, Topo, etc.	$20,000	Data: TM, Topo, etc.	$32,000	Data: TM, Topo, etc.	$35,000	Data: TM, Topo, etc.	$55,000	Data: TM, Topo, etc.	$70,000	Data: TM, Topo, etc.
MCST	Computer Time	$9,022	Computer Time	$13,805	Computer Time	$57,379	Computer Time	$83,356	Computer Time	$137,986	Computer Time
MCST Total		$364,915		$450,869		$1,010,703		$1,457,885		$1,706,138	
Menzel	Additional Memory and Upgrades to IBM R6000 workstation, Exabyte 8mm tape and maintenance	$20,000	IBM R6000 and mainentance	$30,000	Upgrade R6000, disk drive, (3) UNIX based workstations and maintenance	$30,000	Awaiting Response on Phasing				
Menzel Total		$20,000		$30,000		$30,000		$0		$0	
Running			Workstations	$45,000					Workstations	$50,000	
Running			Upgrades	$5,000	Upgrades	$5,000	Upgrades	$5,000			
Running									Image Display	$90,000	
Running	Software Lic.	$22,200	Software Lic.	$23,400	Software Lic.	$24,700	Software Lic.	$26,000	Software Lic.	$27,400	Software Lic.
Running	Drives	$10,000									
Running	Printers	$30,000									
Running									Documentation	$10,000	
Running	Personal Computers	$10,000	Personal Computers	$10,000	Personal Computers	$10,000	Personal Computers	$10,000	Personal Computers	$10,000	Personal Computers
Running	Maintenance	$10,000	Maintenance	$10,000	Maintenance	$10,000	Maintenance	$10,000	Maintenance	$10,000	Maintenance
Running Total		$82,200		$83,400		$49,700		$51,000		$197,400	
Salomonson	SGI Indigo Workstation	$20,000	X-terminal	$4,000	Upgrade SGI workstation processor and increase memory to 250MB	$12,000			Add SGI workstation	$20,000	
Salomonson			4GB disk drive	$8,000	CD-ROM drive	$1,000	2GB disk drive	$3,000	Add 2GB disk	$3,000	Add 2GB disk
Salomonson			8mm Exabyte tape unit	$3,000	10GB Magneto-Optical Jukebox	$9,000	PC running UNIX	$4,000			Add CD ROM drive
Salomonson			PCI Image Processing Software	$8,000	Image Recorder and Color Printer	$17,000					Add CD ROM Recorder
Salomonson	Maintenance	$1,000	Maintenance	$2,000	Maintenance	$4,000	Maintenance	$4,000	Maintenance	$4,000	Maintenance
Total		$21,000		$25,000		$43,000		$11,000		$27,000	
Slater	Sun workstations		X-terminal	$5,000	Sun workstations	$78,000	Sun workstations	$15,000	Sun workstations	$15,000	Sun workstations
Slater	Workstation Hardware Upgrades	$8,000	Workstation Hardware Upgrades	$8,000	Workstation Hardware Upgrades	$20,000	Workstation Hardware Upgrades	$10,000	Workstation Hardware Upgrades	$10,000	Workstation Hardware Upgrades
Slater	Disk Drives	$4,000			Monitors	$6,000	Optical Disk	$6,000			Optical Disk

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	93 Items	93 Costs	94 Items	94 Costs	95 Items	95 Costs	96 Items	96 Costs	97 Items	97 Costs	98 Items
Slater	Tape Drives				Tape Drives	$14,000					Tape Drives
Slater	Memory	$1,000			Memory	$13,000	Memory	$13,000			Memory
Slater	Networking				Networking	$19,000					
Slater	Software licenses	$8,000	Software licenses	$6,000	Software licenses	$42,000	Software licenses	$25,000	Software licenses	$25,000	Software licenses
Slater	Portable and desktop PC's	$11,000			Portable and desktop PC's	$16,000			Portable and desktop PC's	$11,000	X-terminal
Slater	Uninter. Power Supply	$1,000			Installation and UPS	$21,000	Uninter. Power Supply	$1,000			Installation and UPS
Slater	Hardware Maintenance	$16,000	Software and Hardware Maintenance	$18,000	Software and Hardware Maintenance	$54,000	Software and Hardware Maintenance	$59,000	Software and Hardware Maintenance	$67,000	Software and Hardware Maintenance
Slater	Supplies	$3,000	Supplies	$6,000	Supplies	$6,000	Supplies	$5,000	Supplies	$6,000	Supplies
Slater	Training	$8,000	Training	$5,000	Training	$1,000	Training	$2,000	Training	$1,000	Training
Slater Total		$60,000		$48,000		$290,000		$136,000		$135,000	
Strahler	Personal Iris 20 MHz Turbo Super Graphics Workstation						Personal Iris 20 MHz Turbo Super Graphics Workstation	$33,557			
Strahler			Upgrade to 4D/340S (Add 2 Processors)	$30,576			Upgrade to 4D/340S (Add 4 Processors)	$67,964			
Strahler			Add-on 1.1GB IPI2 Disk Server Upgrade	$17,199							
Strahler	PCI Imaging Processing Software for 4 IRIS W/S, servers	35,123			Server Unit- w/ 8 MB Memory	$176,501			Additional 30.9GB RW Optical Disk Library	$78,819	327 GB 12" WORM Library Unit w/ 2 Optical Disk Drives
Strahler	(2)Macintosh Computer Systems	$11,306			(2)Macintosh Computer Systems	$12,533					(2)Macintosh Computer Systems
Strahler	Apple LaserWriter II NTX	$4,631									Apple LaserWriter II NTX
Strahler							NFS and Software Devel. Package	$1,351			NFS and Software Devel. Package
Strahler	PC Software Packages	$2,530			PC Software Packages	$2,966					PC Software Packages
Strahler	Maintenance	$23,687	Maintenance	$28,151	Maintenance	$45,891	Maintenance	$58,642	Maintenance	$66,639	Maintenance
Strahler Total		$77,277		$75,926		$237,891		$161,514		$145,458	
Vanderbilt			Upgrade Sun workstation, add 128MB memory and pay for computer time	$55,000	10GB disk storage	$35,000	Additional disk storage and computer center charges	$35,000	Replace Sun workstation with a TBD system and pay for computing charges	$55,000	Upgrade (TBD) computer, purchase disk storage and pay for computer time
Wan	1.6GB disk storage	$4,000	RISC workstation	$6,000	2 Processor RISC computer	$82,000	Add one processor to multi-processor RISC	$37,000	Add one processor to multi-processor RISC	$30,000	Image Processing Workstation
Wan	portable computer	$5,000									
Wan	maintenance	$2,000	maintenance	$2,000	maintenance	$2,000	maintenance	$2,000	maintenance	$3,000	maintenance
Wan Total		$11,000		$8,000		$84,000		$39,000		$33,000	

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
Abbott	$444,000	Dedicated Data Management System with local disk and memory	$463,000	Data Processing System Upgrades	$250,000	Data Processing and Visualization Systems Upgrades	$275,000
Abbott	$250,000	Disk Storage and Memory Upgrades	$75,000	Storage System upgrads	$150,000	Workstation Upgrades	$50,000
Abbott	$53,000	Upgrade visualization workstation and file server	$75,000	File Server Upgrades	$150,000	Storage, network upgrades	$182,000
Abbott	$25,000	Laser Printer	$15,000	Laser Printer	$14,000		
Abbott		Color Laser Printer	$35,000	Network Upgrades	$75,000		
Abbott		Video display & recorder upgrades	$55,000	Desktop Workstation Upgrades	$66,000		
Abbott Total	$772,000		$718,000		$705,000		$507,000
Brown	$10,000	Printer modem	$5,000	Printer modem	$5,000	Printer modem	$5,000
Brown	$2,928	(Networking)	$1,546	(Networking)	$1,633	(Networking)	$1,724
Brown	$15,000	Software Maintenance	$7,500	Software Maintenance	$7,500	Software Maintenance	$7,500
Brown	$50,000						
Brown	$40,000						
Brown	$7,322	Supplies	$3,866	Supplies	$4,083	Supplies	$4,311
Brown Total	$125,250		$17,912		$18,216		$18,535
Carder	$18,000	Additional FDDI	$25,000	Additional FDDI LAN	$20,000	Additional FDDI LAN	$15,000
Carder	$16,000	Add 20GB disk storage	$20,000	Full Production	$120,000	Additional Memory	$24,000
Carder	$70,000						
Carder							
Carder	$5,000						
Carder	$7,000	UNIX workstation	$7,000	(2)UNIX based PCs for	$12,000		
Carder Total	$116,000		$52,000		$152,000		$39,000
Clark							
Clark	$20,000					30GB disk storage	$30,000
Clark	$17,000					Image display	$15,000
Clark	$6,000					printers	$6,000
Clark	$27,000	Software Licenses	$22,000	Software Licenses	$22,000	Software Licenses	$102,000
Clark	$25,000	upgrades	$5,000	upgrades	$5,000	upgrades	$25,000
Clark				Network	$20,000		
Clark				UPS	$2,000	UPS	$2,000
Clark	$36,000					Personal computers	$36,000
Clark						installation	$4,000
Clark	$25,000	maintenance	$25,000	maintenance	$25,000	maintenance	$25,000

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
Clark	$8,000	supplies	$8,000	supplies	$8,000	supplies	$8,000
Clark Total	$164,000		$60,000		$82,000		$253,000
Esaias		Workstations	$50,000				
Esaias	$18,000	Upgrades/memory	$18,000	Upgrades/Memory	$18,000	Upgrades/Memory	$18,000
Esaias							
Esaias	$20,000	Software Lic.	$20,000	Software Lic.	$20,000	Software Lic.	$25,000
Esaias	$20,000	Media(Optical	$50,000	Media(Optical	$20,000	Media(Optical	$20,000
Esaias							
Esaias	$5,000	Printers/Modems	$10,000	Printers/Modems	$5,000	Printers/Modems	$5,000
Esaias				Server-Micro	$100,000		
Esaias	$5,000	Networking	$5,000	Networking	$5,000	Networking	$5,000
Esaias	$5,000	Documentation	$5,000	Documentation	$5,000	Documentation	$5,000
Esaias						Personal Computers	$15,000
Esaias				Installation	$10,000		
Esaias	$20,000	Maintenance	$20,000	Maintenance	$20,000	Maintenance	$20,000
Esaias	$10,000	Supplies	$10,000	Supplies	$10,000	Supplies	$10,000
Esaias				UPS	$4,000		
Esaias Total	$103,000		$188,000		$217,000		$123,000
Evans							
Evans	$10,000	Software Lic.	$10,000	Software Lic.	$10,000	Software Lic.	$10,000
Evans	$100,000	(Disk, Tape) Media	$200,000	(Disk, Tape) Media	$200,000	(Disk, Tape) Media	$200,000
Evans	$90,000					Disk System, Mem.	$90,000
Evans							
Evans	$10,000					Display, Printers	$10,000
Evans	$50,000	Printer, Film Sup.	$50,000	Printer, Film Sup.	$50,000	Printer, Film Sup.	$50,000
Evans							
Evans							
Evans	$150,000	Maintenance	$150,000	Maintenance	$150,000	Maintenance	$150,000
Evans	$5,000	Video Equip	$5,000	Video Equip	$5,000		
Evans Total	$415,000		$415,000		$415,000		$510,000
Gordon	$47,000	(1) DEC AXP	$155,000	Upgrade existing	$50,000	Upgrade existing	$75,000

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
Gordon							
Gordon							
Gordon							
Gordon							
Gordon	$15,000	Maintenance	$15,000	Maintenance	$31,000	Maintenance	$31,000
Gordon Total	$62,000		$170,000		$81,000		$106,000
Hoge	$8,000	Upgrades	$8,000	Upgrades	$8,000	Upgrades	$8,000
Hoge							
Hoge							
Hoge							
Hoge							
Hoge							
Hoge							
Hoge	$3,000	Maintenance	$3,000	Maintenance	$3,000	Maintenance	$3,000
Hoge	$4,000	Supplies	$4,000	Supplies	$4,000	Supplies	$4,000
Hoge Total	$15,000		$15,000		$15,000		$15,000
Huete							
Huete	$27,600	Memory	$24,600				
Huete	$12,400	Image Display	$45,000				
Huete	$27,000	Software Lic.	$24,000	Software Lic.	$24,000	Software Lic.	$20,000
Huete		Drives	$14,660				
Huete	$15,000						
Huete	$3,500						
Huete	$12,200	Documentation	$12,920	Documentation	$13,682	Documentation	$14,490
Huete	$7,784	Mainframe Computers	$8,234	Mainframe Computers	$8,729	Mainframe Computers	$9,244

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
Huete	$24,200						
Huete	$23,320	Maintenance	$24,695	Maintenance	$26,152	Maintenance	$27,695
Huete	$6,000						
Huete	$10,800	Operations (Supplies)	$11,437	Operations (Supplies)	$12,112	Operations (Supplies)	$12,826
Huete Total	$169,804		$165,546		$84,675		$84,255
Justice	$100,000	Full production compute server	$200,000	Upgrade memory and mass storage on production compute server	$100,000		
Justice	$20,000	(3) Macintosh Systems	$30,000	Add backup and printing peripherals to server	$50,000	Expand I/O on server	$50,000
Justice	$100,000	High speed LAN hardware	$50,000	100GB Rewritable Optical Library	$100,000	High capacity RAM disk	$100,000
Justice	$20,000			Upgrade and expand network	$30,000		
Justice	$40,000						
Justice	$10,000						
Justice							
Justice							
Justice Total	$290,000		$280,000		$280,000		$150,000
Kaufman	$20,000	Workstations	$20,000	Workstations	$20,000	Workstations	$20,000
Kaufman	$20,000	Mainframe Computers	$20,000	Mainframe Computers	$20,000	Mainframe Computers	$20,000
Kaufman	$6,000	Personal Computers	$2,000	Personal Computers	$2,000	Personal Computers	$2,000
Kaufman Total	$46,000		$42,000		$42,000		$42,000
King	$150,000	memory)	$50,000	disk, memory)	$50,000	memory)	$50,000
King		computers	$35,000	Quadra computers	$40,000		
King		Spyglass)	$10,000	Upgrade color printer	$15,000		

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
King							
King	$40,000						
King	$15,000						
King		(2) Color Powerbooks	$10,000				
King	$5,000						
King							
King total	$210,000		$105,000		$105,000		$50,000
MCST	$34,500	SW	$33,250	SW	$28,250	SW	$32,250
MCST	$469,068	Scientific Analysis SW	$490,094	Scientific Analysis SW	$504,498	Scientific Analysis SW	$519,420
MCST	$890,325	Computer Systems	$922,984	Computer Systems	$940,671	Computer Systems	$984,536
MCST	$366,905	optical drives, etc.)	$377,954	optical drives, etc.)	$401,560	optical drives, etc.)	$405,656
MCST	$180,243	Maintenance & Supplies	$185,032	Maintenance & Supplies	$187,481	Maintenance & Supplies	$190,018
MCST	$70,000	Data: TM, Topo, etc.	$70,000	Data: TM, Topo, etc.	$70,000	Data: TM, Topo, etc.	$70,000
MCST	$183,250	Computer Time	$259,176	Computer Time	$268,506	Computer Time	$278,172
MCST Total	$2,194,291		$2,338,490		$2,400,966		$2,480,052
Menzel							
Menzel Total	$0		$0		$0		$0
Running							
Running		Upgrades	$5,000	Upgrades	$5,000	Upgrades	$5,000
Running							
Running	$28,900	Software Lic.	$30,500	Software Lic.	$32,100	Software Lic.	$33,800
Running		Drives	$10,000				
Running		Printers	$30,000				
Running							
Running	$10,000	Personal Computers	$10,000	Personal Computers	$10,000	Personal Computers	$10,000
Running	$10,000	Maintenance	$15,000	Maintenance	$15,000	Maintenance	$15,000
Running Total	$48,900		$85,500		$62,100		$48,800
Salomonson		Upgrade or replace workstations, increasing cpu and storage	$5,000	30GB Additional Storage Capacity	$30,000		
Salomonson	$3,000						
Salomonson	$1,000	8mm (or other technology) drive	$3,000				
Salomonson	$10,000						
Salomonson	$5,000	Maintenance	$6,000	Maintenance	$6,000	Maintenance	
Total	$19,000		$14,000		$36,000		$0
Slater	$49,000			Sun workstations	$15,000		
Slater	$10,000	Workstation Hardware Upgrades	$15,000	Workstation Hardware Upgrades	$15,000		
Slater	$6,000			Optical Disk	$6,000		

Table 4. SCF Hardware and Software Purchases 1992-2000

Team	98 Costs	99 Items	99 Costs	'00 Items	00 Costs	'01 Items	01 Costs
Slater	$14,000						
Slater	$13,000						
Slater							
Slater	$51,000	Software licenses	$18,000	Software licenses	$23,000		
Slater	$5,000	Portable and desktop PC's	$16,000	X-terminal	$5,000		
Slater	$12,000	UPS	$1,000				
Slater	$67,000	Software and Hardware Maintenance	$69,000	Hardware Maintenance	$69,000		
Slater	$11,000	Supplies	$9,000	Supplies	$9,000		
Slater	$4,000	Training	$1,000	Training	$2,000		
Slater Total	$242,000		$129,000		$144,000		
Strahler				Personal Iris 20 MHz Turbo Super Graphics Workstation	$42,210		
Strahler							
Strahler							
Strahler	205,607			327 GB 12" WORM Library Unit w/ 2 Optical Disk Drives	$230,571		
Strahler	14,865			(2)Macintosh Computer Systems	$16,671		
Strahler	$6,088						
Strahler	$758			NFS and Software Devel. Package	$850		
Strahler	$3,518			PC Software Packages	$3,946		
Strahler	$90,838	Maintenance	$90,967	Maintenance	$118,104	Maintenance	$118,310
Strahler Total	$95,114		$90,967		$412,352		$118,310
Vanderbilt	$75,000	disk storage	$35,000	computer charges	$20,000		
Wan	$20,000	Add one processor and other upgrades to RISC	$40,000	Add one processor and other upgrades to	$45,000	Add one processor and other upgrades to	$48,000
Wan							
Wan	$3,000	maintenance	$4,000	maintenance	$4,000	maintenance	$4,000
Wan Total	$23,000		$44,000		$49,000		$52,000

DATA DICTIONARY FOR TLCF DATA FLOWS

ALGORITHMS consist of the executable programs for science product generation, source code of these executable programs, job control scripts, and algorithm documentation. Algorithms are the result of new or updated science algorithms passing through the integration and test process, involving the scientist and the algorithm integration and test staff of the PGS. After formal approval, algorithms are delivered by the PGS to the DADS for storage, and are retrieved as needed to support product production. The DADS shall also archive algorithms contributed as EOSDIS resources by other data centers. Algorithms shall be orderable and distributed to authorized users. Some frequently used algorithms may also be kept on line in the PGS.

ALGORITHM UPDATES are delivered to the PGS's integration and test environment by scientists at an SCF. They represent changes to existing production algorithms, or a new algorithm to produce a new Standard Product. Algorithm updates include the source code for the candidate algorithm, its associated documentation, and a job step control skeleton. The source code will be compiled to form an executable program suite as part of the integration and test process. The job step control skeleton contains instructions that control the sequence of execution of, and the interchange of data between programs from the executable program suite. Test data sets and calibration data should also be included.

ANCILLARY DATA refers to any data, other than Standard Products, that are required as input in the generation of a Standard Product. This may include selected engineering data from the EOS platform, ephemeris data, as well as non-EOS ancillary data. All ancillary data is received by the PGS from the DADS.

CALIBRATION is the collection of data required to perform calibration of the instrument science data, instrument engineering data, and the spacecraft or platform engineering data. It includes pre-flight calibration measurements, in-flight calibrator measurements, calibration equation coefficients derived from

calibration software routines, and ground truth data that are to be used in the data calibration processing routine.

CORRELATIVE data are scientific data needed to evaluate and validate EOS data products.

DATA QUALITY REQUEST is a request issued by the PGS to a scientist at an SCF to perform QA of a particular product before future processing or distribution. A time window is applied to the request in keeping with the production schedule.

DOCUMENTS are the hardcopy or digitized references or records about an instrument or the products generated from its data. These shall be archived at the DADS.

INTERACTIVE SESSION DIALOG consists of messages that flow between a scientist at an SCF and the PGS that support general communication with the Integration and Test Service. This includes logins, mail messages, etc.

L0-L4 DATA PRODUCTS consist of L0 Data Products from the IPs, the ADCs and ODCs, and L1-L4 Standard Products produced in the PGS.

L1-L4 SPECIAL PRODUCTS are special science data products consisting of L1A, L1B, L2, L3, and L4 which are produced at the SCFs. These shall be archived at the DADS and distributed to authorized requesters.

METADATA is data which describes the content, format, and utility of a Standard Product. It includes standard metadata (i.e., algorithm and calibration numbers, size of product, date created, etc.), algorithm-derived metadata, QA information from the PI's, summary statistics and an audit trail. Metadata is received by each DADS with the corresponding data sets. DADS validates it physically, updates it with inventory information, enters it into a distributed database (to which the IMS has access), and archives it. Metadata

about special products produced at SCF shall be sent to DADS along with their associated data products.

METADATA UPDATES are additional or changed metadata items relating to a previously delivered product.

ON TIME QA is a response to a data quality request that is received within the established production time window. It is received from a scientist at an SCF. It consists of data which will be used to complete the QA fields of the metadata. Overdue QA responses are sent directly to the DADS.

TEST PRODUCTS are science products generated by new or updated algorithms during the integration and test period. Test products are delivered to scientists at an SCF.

TEST PRODUCT REVIEWS are evaluations of test products that are used to determine how to proceed in the integration and test process for a new or updated algorithm. A review may indicate the need for further algorithm refinement, or it may indicate that a candidate algorithm is ready for formal adoption into the production environment. Test product reviews are received by the PGS from scientists at an SCF.